CBSE Delhi 2014

Chemistry (Theory)

Time: 3 Hrs **Max. Marks: 70**

General Instructions:

(a) *All questions are compulsory.*
(b) *Question numbers 1 to 8 are very short answer questions and carry 1 mark each.*
(c) *Question numbers 9 to 18 are short answer questions and carry 2 marks each.*
(d) *Question numbers 19 to 27 are also short answer questions and carry 3 marks each.*
(e) *Question numbers 28 to 30 are long answer questions and carry 5 marks each.*
(f) *Use Log Tables, if necessary. Use of calculators is not allowed.*

---

1. Give one example each of 'oil in water' and 'water in oil' emulsion.

Solution

The examples of Sol and Gel are given below:
Sol – Milk of Magnesia
Gel – Butter

2. Which reducing agent is employed to get copper from leached low-grade copper ore?

Solution

Through the process of leaching using bacterial substance, the main reducing agents are iron (scrap) and H_2 (Hydrogen)

3. Which of the following is more stable and complex and why?
$[Co(NH_3)_6]^{3+}$ and $[Co(en)_3]^{3+}$

Solution

$[Co(en)_3]^{3+}$ is more stable as it forms a chelate complex due to the presence of bidentate ligand, that is (en)

4. Write the IUPAC name of the compound

$$CH_3 - \underset{\displaystyle OH}{\underset{|}{CH}} - CH_2 - COOH$$

Solution

3-hydroxy butanoic acid

5. Which of the following isomers is more volatile: *o*-nitrophenol or *p*-nitrophenol?

Solution

Ortho nitrophenol is more steam volatile because it has intramolecular hydrogen bonding.

6. What are isotonic solutions?

Solution

Isotonic solutions are those solutions which have same osmotic pressure.

7. Arrange the following in increasing order of solubility in water
$C_6H_5NH_2$, $(C_2H_5)_2NH$, $C_2H_5NH_2$

Solution

$C_6H_5NH_2 < C_2H_5NH_2 < (C_2H_5)_2NH$

8. Which of the two components of starch is water soluble?

Solution

Starch has two components, that is amylase and amylopectin. Amylase is a water soluble component.

9. An element with density 11.2 g cm^{-3} forms an fcc lattice with edge length of 4×10^{-8} cm. Calculate the atomic mass of the element. (Given: $N_A = 6.022 \times 10^{23}$ mol^{-1}.)

Solution

Using the formula,

$$d = Z \cdot M / a^3 \cdot N_A$$

$Z = 4$ for fcc lattice
$a = 4 \times 10^{-8}$ cm
$d = 11.2$ g/cm^3
M = ?
$N_A = 6.022 \times 10^{23}$/mol
Substituting all the values
$M = a^3 \cdot N_A \cdot d/Z$
$= (4 \times 10^{-8})^3 \times 6.022 \times 10^{23} \times 11.2/4 = 107.91$ g/mol

10. Examine the given defective crystal

A^+	B^-	A^+	B^-	A^+
B^-	0	B^-	A^+	B^-
A^+	B^-	A^+	0	A^+
B^-	A^+	B^-	A^+	B^-

Answer the following questions:
(a) What type of stoichiometric defect is shown by the crystal?
(b) How is the density of the crystal affected by this defect?
(c) What type of ionic substances show this defect?

Solution

(a) Schottky defect
(b) Schottky defect decreases the density of the crystal.
(c) The ionic substances in which the cation and anion are of almost similar sizes, for example, NaCl, KCl, etc.

11. Calculate the mass of compound (molar mass = 256 g mol^{-1}) to be dissolved in 75 g of benzene to lower its freezing point by 0.48 K ($K_f = 5.12$ K kg mol^{-1}).

Solution

Using the formula

$$\Delta T_f = K_f \cdot m$$

or $\Delta T_f = K_f \cdot W_2 \cdot 1000 / M_2 \cdot W_1$
Given
$\Delta T_f = 0.48$ K
$K_f = 5.12$ K kg/mol

W_1 = 75 g
M_2 = 256 g/mol
W_2 = ?
Substituting all the values,
$0.48 = 5.12 \times W_2 \times 1000/256 \times 75$
$0.48 \times 256 \times 75/5.12 \times 1000 = W_2$
W_2 = 1.8 g

12. Define an ideal solution and write one of its characteristics.

Solution

Ideal solutions are those which obey Raoult's law at all range of concentration.
Characteristics are:
$\Delta H_{mix} = 0$
$\Delta V_{mix} = 0$

13. Write two differences between 'order of reaction' and 'molecularity of reaction'.

Solution

Order: The sum of the powers of the concentration of the reactants in the final rate law expression is called the order of the reaction.
It can be zero as well as in fraction.
Molecularity: The number of reacting species taking part in an elementary reaction is called molecularity.
It cannot be zero and non-integer.

14. Outline the principles behind the refining of metals by the following methods:
(a) Zone refining method
(b) Chromatographic method

Solution

(a) Zone refining method: It is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal. It is used to purify semiconductors such as silicon and germanium.
(b) Chromatographic method: It is based on the principle that the different components of a mixture are absorbed differently on the adsorbent. Example, it is used to refine Al_2O_3.

15. Complete the following chemical equations:
(a) $Ca_3P_2 + H_2O \rightarrow$ (b) $Cu + H_2SO_4$ (conc.)

Solution

(a) $Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$
(b) $Cu + 2H_2SO_4(conc.) \longrightarrow CuSO_4 + SO_2 + 2H_2O$

OR

Arrange the following in the order of property indicated against each set:
(a) HF, HCl, HBr, HI – increasing bond dissociation enthalpy.
(b) H_2O, H_2S, H_2Se, H_2Te – increasing acidic character.

Solution

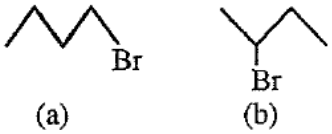
(a) HI<HBr<HCl<HF (increasing bond dissociation enthalpy)
(b) $H_2O < H_2S < H_2Se < H_2Te$ (increasing acidic character)

16. Write the IUPAC name of the complex $[Cr(NH_3)_4Cl_2]^+$. What type of isomerism does it exhibit?

Solution

IUPAC: tetraamminedichloridochromium(III)
It exhibits geometrical isomerism (*cis* and *trans*)

17. (i) Which alkyl halide from the following pair is chiral and undergoes faster S_N2 reaction?



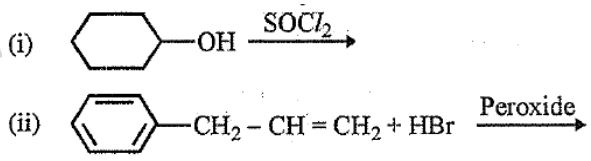
(a) (b)

(ii) Out of S_N1 and S_N2, which reaction occurs with
(a) inversion of configuration
(b) racemisation

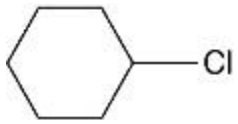
Solution

(i) Alkyl halide (b) is chiral and alkyl halide (a) will undergo SN2 reaction faster as it is a primary halide.
(ii) (a) Inversion of configuration = S_N2 reaction
(b) Racemisation = S_N1 reaction

18. Draw the structure of major monohalo product in each of the following reactions:



(i)



(ii) $C_6H_5–CH_2–CH_2–CH_2Br$

19. (a) In reference to Freundlich adsorption isotherm, write the expression for adsorption of gases on solids in the form of an equation.
(b) Write an important characteristic of lyophilic sols.
(c) Based on type of particles of dispersed phase, give one example each of associated colloid and multimolecular colloid.

Solution

(a) Freundlich adsorption isotherm equation

$$x/m = kP^{1/n}$$

where x is the mass of the gas adsorbed on mass m of the adsorbent at pressure P, k and n are the constants which depends on the nature of the adsorbent and the gas (at a particular temp.)
or $\log x/m = \log k + 1/n \log P$
(b) lyophilic sols are solvent loving sols. They are also reversible sols.
(c) example of associated colloid: soap (sodium stearate $C_{17}H_{35}COONa$)
Example of multimolecular colloid: gold sol

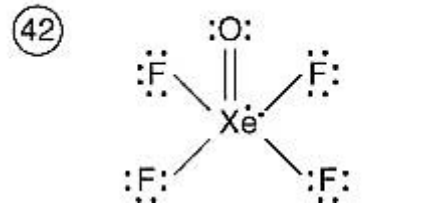
20. (a) Draw the structures of the following molecules: (i) $XeOF_4$ and (ii) H_2SO_4.
(b) Write the structural difference between white phosphorus and red phosphorus.

Solution

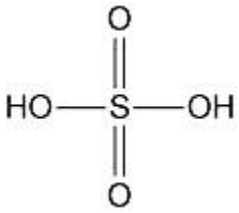
(a)

(i)

$XeOF_4$ Xenon oxytetrafluoride



(ii)



(b)

White phosphorous consists of a discrete tetrahedral P_4 molecule

Red phosphorous is polymeric, has chains of P_4 molecules linked in polymeric manner.

21. Account for the following:
(i) PCl_5 is more covalent than PCl_3.
(ii) Iron on reaction with HCl forms $FeCl_2$ and not $FeCl_3$.
(iii) The two O–O bond lengths in the ozone molecule are equal.

Solution

(i) Phosphorous in +5 oxidation state have less tendency to loose electrons than in +3 oxidation states. So, it has more tendency to share electrons in +5 oxidation state, due to which PCl_5 is more covalent than PCl_3.

(ii) $Fe + 2HCl \longrightarrow FeCl_2 + H_2$

The hydrogen liberated in the reaction prevents the oxidation of $FeCl_2$ to $FeCl_3$

(iii) Because of resonance, both the oxygen–oxygen atoms have partial double bond character and thus there bond lengths are also equal.

22. The following data were obtained during the first-order thermal decomposition of SO_2Cl_2 at a constant volume:

$$SO_2Cl_2(g) \rightarrow SO_2(g) + Cl_2(g)$$

Experiment	Time/s^{-1}	Total pressure (atm)
1	0	0.4
2	100	0.7

Calculate the rate constant. (Given: log 4 = 0.6021, log 2 = 0.3010)

Solution

Consider the reaction

	SO_2Cl_2	$\rightarrow$	SO_2 +	Cl_2
Initial pressure	P_0		0	0
At time t	$P_0–P$		P	P

Total $P_T = P_0–P + P + P$

$P_T = P_0 + P$

$P = P_T–P_0$

For first-order reaction

$k = 2.303/t \log a/a – x$

$a–x = P_0 – (P_T – P_0) = P_0–P_T + P_0 = 2P_0P_T$

$k = 2.303/100 \log 0.4/(0.4 \times 2 – 0.7)$

$= 2.303/100 \log 0.4/0.1$

$= 2.303/100 \log 4$

$= 2.303/100 (0.6021)$

$= 1.3 \times 10^{-3}\ s^{-1}$

23. (i) Give two examples of macromolecules that are chosen as drug targets.
(ii) What are antiseptics? Give an example.
(iii) Why is the use of aspartame limited to cold foods and soft drinks?

Solution

(i) Carbohydrates and proteins are the examples of macromolecules chosen as drug targets.
(ii) Antiseptics are the chemical substances which prevents the growth of micro-organisms and even kill them. For example, furacin, soframycin.
(iii) Aspartame decomposes at cooking temperature, so it can be used only in cold foods and drinks.

24. (i) Deficiency of which vitamin causes night-blindness?
(ii) Name the base that is found in nucleotide of RNA only.
(iii) Glucose on reaction with HI gives *n*-hexane. What does this suggest about the structure of glucose?

Solution

(i) Deficiency of vitamin A causes night blindness.
(ii) Uracil is the base found in RNA only.
(iii) This reaction suggests all the six carbon atoms in glucose molecules are arranged in a straight chain.

25. After the ban on plastic bags, students of a school decided to make people aware of the harmful effects of plastic bags on the environment and Yamuna River. To make the awareness more impactful, they organised rally by joining hands with other schools and distributed paper bags to vegetable vendors, shopkeepers and departmental stores. All the students pledged not to use polythene bags in the future to save the Yamuna River.
After reading the above passage, answer the following questions:
(i) What values are shown by the students?
(ii) What are biodegradable polymers? Give one example.
(iii) Is polythene a condensation or an addition polymer?

Solution

(i) Values shown by the students are: Their concern for the environment, awareness, responsible citizen.
(ii) Polymers which are degraded by bacteria and which do not cause any threat to the environment are called biodegradable polymers.

(iii) Polyethene is an addition polymer.

26. (a) Write the mechanism of the following reaction:

$$CH_3CH_2OH \xrightarrow{HBr} CH_3CH_2Br + H_2O$$

(b) Write the equation involved in Reimer–Tiemann reaction.

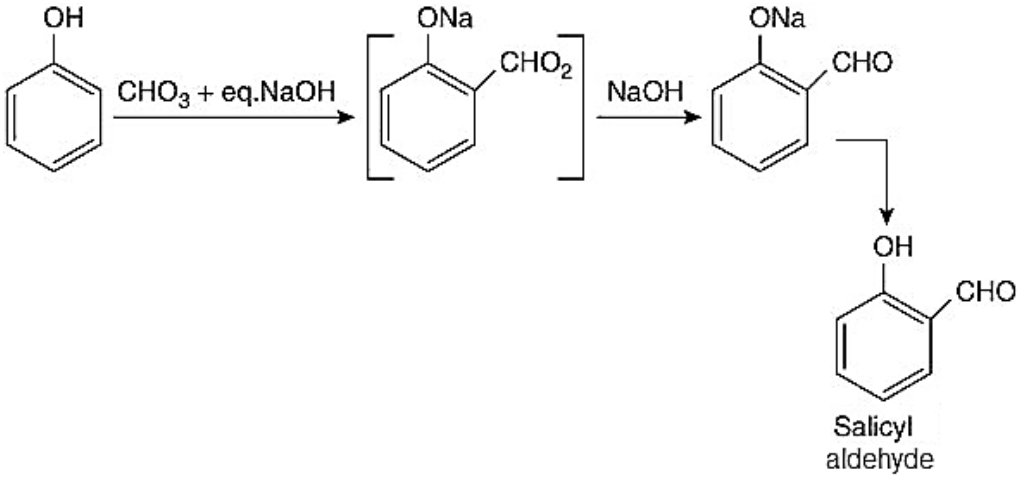
Solution

(a) and (b)

$$CH_3CH_2OH + H^+ \longrightarrow CH_3CH_2 - \overset{\overset{H}{\uparrow}}{\overset{+}{O}}\!\!-H$$

$$CH_3CH_2 - \overset{\overset{H}{\uparrow}}{\overset{+}{O}}\!\!-H \rightleftharpoons CH_3CH_2^+ + H_2O$$

$$CH_3CH_2^+ + Br^- \longrightarrow CH_3CH_2Br$$



27. Give the structures of A, B and C in the following reactions:

(i) $CH_3Br \xrightarrow{KCN} A \xrightarrow{LiAlH_4} B \xrightarrow[273\ K]{HNO_2} C$

(ii) $CH_3Br \xrightarrow[\Delta]{NH_3} A \xrightarrow{Br_2+KOH} B \xrightarrow{CHCl_3+NaOH} C$

Solution

(i) $CH_3Br + KCN \longrightarrow CH_3CN + LiAlH_4 \longrightarrow CH_3CH_2NH_2 + HNO_2 \longrightarrow CH_3CH_2OH$

(ii) $CH_3COOH + NH_3 \longrightarrow CH_3CONH_2 + Br_2 + KOH \longrightarrow CH_3NH_2 + CHCl_3 + NaOH \longrightarrow CH_3NC$

OR

How will you convert the following:

(i) Nitrobenzene into aniline

(ii) Ethanoic acid into methanamine

(iii) Aniline into N-phenylethanamide

(Write the chemical equations involved.)

Solution

(i) $C_6H_5NO_2 + 6[H] \xrightarrow{Fe/HCl} C_6H_5NH_2 + 2H_2O$

(ii) $CH_3COOH + NH_3 \rightarrow CH_3CONH_2 + Br_2 + KOH \rightarrow CH_3NH_2$

(iii) $C_6H_5NH_2 + CH_3COOCOCH_3 \longrightarrow C_6H_5NHCOCH_3 + CH_3COOH$

28. (a) Define the following terms:

(i) Limiting molar conductivity

(ii) Fuel cell

(b) Resistance of a conductivity cell filled with 0.1 mol L^{-1} KCl solution is 100 Ω. If the resistance of the same cell when filled with 0.02 mol L^{-1} KCl solution is 520 Ω. Calculate the conductivity and molar conductivity of 0.02 mol L^{-1} KCl solution. The conductivity of 0.1 mol L^{-1} KCl solution is 1.29×10^{-2} Ω^{-1} cm^{-1}.

Solution

(a)

(i) Limiting molar conductivity: It is defined as the sum of limiting ionic conductivities of the cation and anion multiplied by their number of ions present in the formula unit of the electrolyte.

$$\Lambda^{m}_{o} = x\lambda^{m}_{o(A)^{y+}} + y\lambda^{m}_{o(B)^{x-}}$$

(ii) Fuel cells convert the energy of combustion of fuels directly into electrical energy.

(b) Given

Conductivity k = 1.29 S/m and resistance R = 100 Ω

Cell constant = conductivity × resistance = 1.29 × 100 = 1.29/m

Conductivity of 0.02 M solution = cell constant/resistance = 129/520 = 0.248 S/m

Concentration C = 0.02 mol/L = 0.02 × 1000 = 20 mol/m^3

$\Lambda_m = K/c = 0.248/20 = 124 \times 10^{-4}$ S m^2 mol^{-1}

OR

(a) State Faraday's first law of electrolysis. How much charge in terms of Faraday is required for the reduction of 1 mol of Cu^{2+} to Cu?

(b) Calculate emf of the following cell at 298 K:

$Mg(s)|Mg^{2+}(0.1\ M)||Cu^{2+}(0.01\ M)|Cu(s)$

[Given $E^{o}_{cell} = +2.71$ V, $1\ F = 96{,}500$ C mol^{-1}]

Solution

(a) Faraday's first law of electrolysis states that the amount of chemical reaction that occurs at any electrode (during electrolysis) by passing a current is directly proportional to the amount of electricity passed through the electrolyte.

$Cu^{2+} + 2e- \rightarrow Cu$

1 mol of Cu requires 2 F of charge, where F = 96,500

(b) The cell reaction is

$Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu$

$E_{cell} = E^{0}_{cell} - 0.059/n \log [Mg^{2+}]/[Cu^{2+}]$

$E_{cell} = 2.71 - 0.059/2 \log (0.1)/(0.01)$

$E_{cell} = 2.71 - 0.059/2 \log 10$ (log 10 = 1)

$E_{cell} = 2.71 - 0.059/2 = 2.681$ V

29. (a) How do you prepare

(i) K_2MnO_4 from MnO_2

(ii) $Na_2Cr_2O_7$ from Na_2CrO_4?

(b) Account for the following:

(i) Mn^{2+} is more stable than Fe^{2+} towards oxidation to +3 state.

(ii) The enthalpy of atomisation is lowest for Zn in 3d series of the transition elements.

(iii) Actinoid elements show wide range of oxidation states.

Solution

(a)

(i) $2MnO_2 + 4KOH + O_2 \longrightarrow 2K_2MnO_4 + 2H_2O$

(ii) $2Na_2CrO_4 + H_2SO_4(conc.) \longrightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$

(b)

(i) The configuration of Mn^{2+} is $3d^5$ which is half filled and extra stable while the configuration of Fe^{2+} is $3d^6$ means it can easily loose an electron to achieve stable gas configuration.

(ii) The energy of atomisation for zinc is the lowest because it has no unpaired electrons so the intermetallic bonding is weakest in it.

(iii) Actinoids show a wide number of oxidation states as there is small energy gap between 5f, 6d and 7s subshells which means all the electrons can take part in bond formation.

OR

(i) Name the element of 3*d* transition series which shows maximum number of oxidation states. Why does it show so?

(ii) Which transition metal of 3*d* series has positive $E^o(M^{2+}/M)$ value and why?

(iii) Out of Cr^{3+} and Mn^{3+}, which is a stronger oxidising agent and why?

(iv) Name a member of the lanthanoid series which is well known to exhibit +2 oxidation state.

(v) Complete the following equation:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow$$

Solution

(i) Mn shows the highest number of oxidation states as Mn^{2+} has maximum number of unpaired electrons.

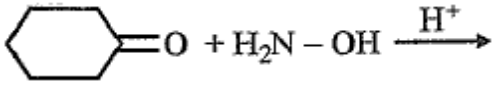
(ii) Copper has positive E^o value because the sum of its enthalpies of sublimation and ionisation is not balanced by hydration enthalpy.

(iii) E^o value for Cr^{3+}/Cr^{2+} is negative while E^o value for Mn^{3+}/Mn^{2+} is positive. So, Mn^{3+} easily undergoes reduction and acts as an oxidising agent while Cr^{2+} can easily undergo oxidation and acts as a reducing agent.

(iv) Europium (+2)

(v) $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

30. (a) Write the products of the following reactions:

(i) 

(ii) $2C_6H_5CHO + \text{conc. } NaOH \rightarrow$

(iii) $CH_3CHO \xrightarrow{Cl_2/P}$

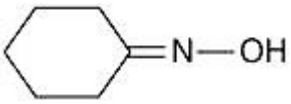
(b) Give simple chemical tests to distinguish between the following pairs of compounds:

(i) Benzaldehyde and Benzoic acid

(ii) Propanal and Propanone

Solution

(a)

(i) 

(ii) $C_6H_5CH_2OH + C_6H_5COONa$ (Cannizaro reaction)

(iii) $CH_2ClCOOH$

(b) Benzaldehyde and benzoic acid

(i) Benzoic acid reacts with sodium carbonate and gives effervescence due to the evolution of CO_2 gas while benzaldehyde does not.

$C_6H_5COOH + Na_2CO_3 \longrightarrow C_6H_5COONa + CO_2 + H_2O$

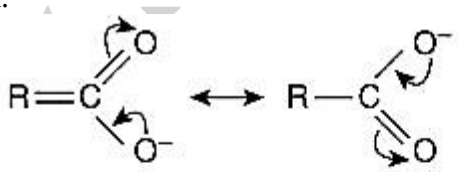
(ii) Propanal and propanone
Propanone will give positive iodoform test while propanal does not.
$CH_3COCH_3 + I_2/NaOH\ CHI_3$ (yellow ppt) + CH_3COONa

OR

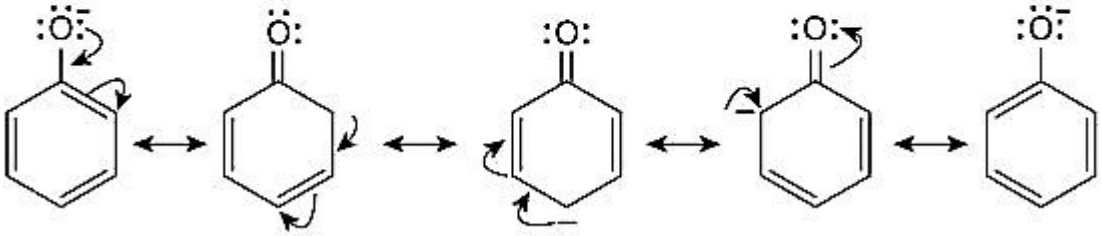
(a) Account for the following:
(i) CH_3CHO is more reactive than CH_3COCH_3 towards reaction with HCN.
(ii) Carboxylic acid is a stronger acid than phenol.
(b) Write the chemical equations to illustrate the following name reactions:
(i) Wolff–Kishner reduction
(ii) Aldol condensation
(iii) Cannizzaro reaction

Solution

(a)
(i) CH_3CHO is more reactive than CH_3COCH_3 towards reaction with HCN due to stearic and electronic reasons. Stearically, the presence of two bulky groups (CH_3) hinders the approach of nucleophile CN^- and electronically the presence of two +I effect methyl groups reduces the electrophilicity of the carbon atom thereby making the attack of CN^- difficult.
(ii) Carboxylic acids are stronger acids than phenols because the carboxylate ion is stabilised by two equivalent structures in which the negative charge is on the more electronegative oxygen atom while in case of phenols, phenoxide ion has non-equivalent resonance structures in which negative charge is on less electronegative carbon atom. So, carboxylate is more stabilised than phenoxide ion.



Carboxylate ion

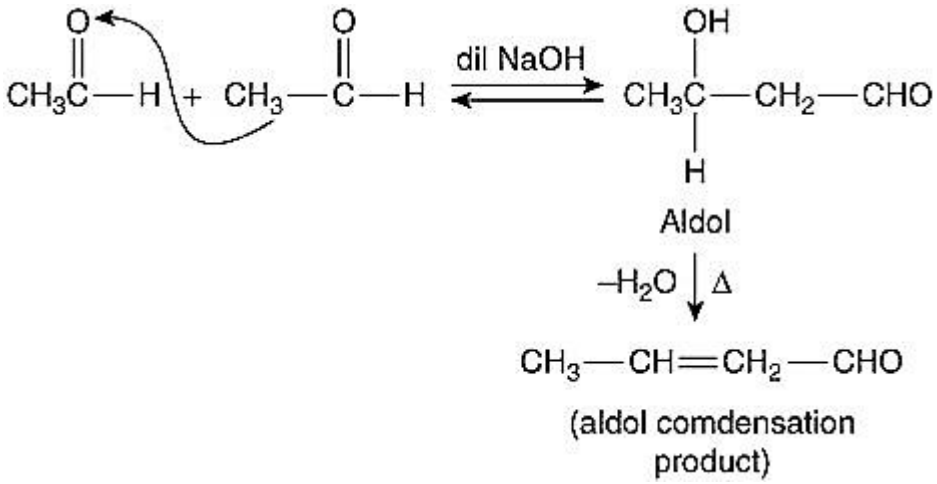


Phenoxide ion

(b)
(i) Wolff–Kishner reduction:
In this reaction, the aldehyde or ketone is heated with hydrazine (NH_2NH_2) and KOH/NaOH in a high boiling solvent such as ethylene glycol.

$$RCHO + NH_2NH_2 \longrightarrow RCH{=}NNH_2 \xrightarrow{KOH/ethylene\ glycol/heat} RCH_3 + N_2$$

(ii) Aldol condensation
Aldehydes and ketones having at least one α-hydrogen undergoes a reaction in the presence of dilute alkali to form β-hydroxy aldehydes(aldol) or ketols, respectively. The aldol thus formed readily loses water to give α,β-unsaturated carbonyl compounds.



(iii) Cannizaro reaction: Aldehydes which do not have an α-hydrogen atom, undergoes self oxidation and reduction reaction on treatment with concentrated alkali. In this reaction, one molecule of aldehyde is reduced to alcohol while other is oxidised to carboxylic acid salt.

$2C_6H_5CHO \xrightarrow{\text{conc. NaOH}} C_6H_5CH_2OH + C_6H_5COONa$